# Development of High Temperature Membrane and Electrode Assembly for Proton Exchange Membrane Fuel Cell Device

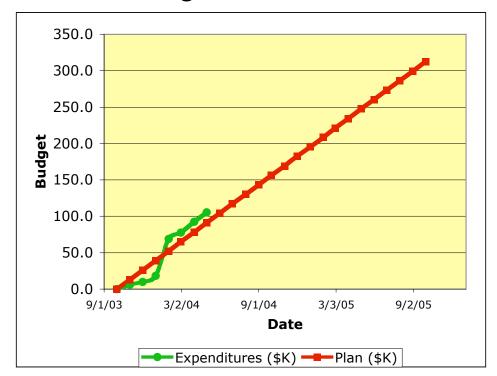
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Oxford Performance Materials (OPM), Inc.
U. Of Connecticut (UConn) Subcontract
May 25, 2004

# **Objectives**

- Overall: Develop MEAs to Operate PEMFC at 120°C
- Ist Six Months: Materials & Processing Development
  - Develop novel polymer blends for 120°C & low RH
  - Establish laboratory capability
  - Fabricate blends into membranes and catalyst layers
- Final 18 Months: MEA Feasibility at 120°C & low RH
  - Characterize membrane resistance and strength
  - Fabricate MEAs from blends & show feasibility
  - Optimize MEA performance
  - Optimize Pt loading in MEA
  - Demonstrate MEA durability (100 hours)

## **Budget**

- •Total Funding = \$312K
- DOE/Contractor = 80/20
- Funding in FY04 = \$156K



## **Technical Barriers and Targets**

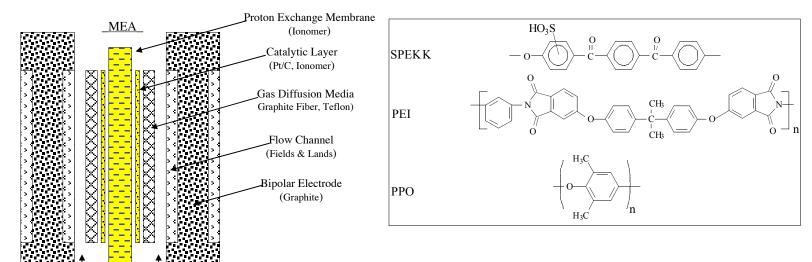
- Proton Conductivity Too Low in Ionomers at Low RH
  - Low (25-50%) Relative Humidity (RH) at 120°C
  - Low RH Reduces Membrane Water Content
  - Water Needed for Grotthuis Conduction Mechanism

## Targets

- Membrane Specific Conductance: 0.1 S/cm @ 120°C, 30%RH
- Membrane Strength: Adequate (20kPa)
- MEA Resistance: 0.1 Ωcm² @ 120°C, 30%RH

## **Technical Approach**

- Replace Nafion© with Novel Polymer Blend
  - Sulfonated Poly Ether Ketone Ketone (sPEKK)
  - Complimentary Polymer (PEI, PBI, etc.) Replaces Water
- Engineer Blend Morphology to Improve Connectivity
  - Connect Isolated Ionic Domains
- Fabricate Prototype MEAs from Blend
  - Substitute Blend for Nafion in Membrane and Catalytic Layer
  - Demonstrate MEA Feasibility at Low RH

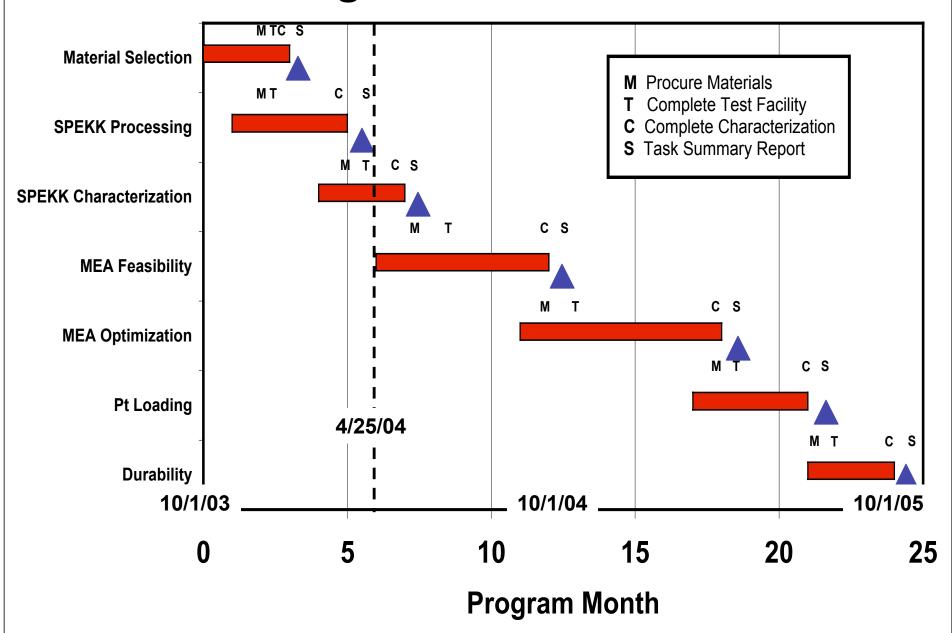


May 25, 20 This pres does not contain any proprietary or confidential information

## **Project Safety**

- Safety Analysis
  - Failure Mode and Effects Analysis (FMEA)
- Safety Issues and Mitigations
  - Hydrogen Flammability
    - + Area Hydrogen detector
    - + Small volumes
    - + Leak testing
  - Electrical Shock
    - + Insulated 120V
  - Hazardous Solvents
    - + Fume hood for drying
  - Flammable Solvents
    - + Flammable solvents cabinet

## **Program Tasks Milestones**

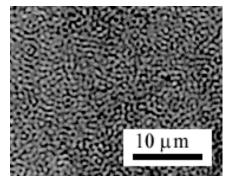


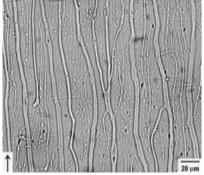
## **Technical Accomplishments**

- Identified Preferred Blend (UConn) Task A
  - sPEKK & PEI
- Set up New Laboratory Capability (OPM)
  - Instron/DSC/TGA
  - Fume hood
  - Membrane conductance vs T and RH
  - Fuel cell tests stations (2)
- Trained Staff in MEA Fabrication (OPM)
  - Decal method similar to Nafion
- Demonstrated sPEKK MEA Feasibility (UConn)
  - 0.35 Ωcm<sup>2</sup> MEA at 80°C

# **Technical Progress (UConn)**

#### **Domain Morphology**





Polymer blend Spinodal morphology

EF oriented polymer morphology

#### **Electric Field Orientation (EFO)**

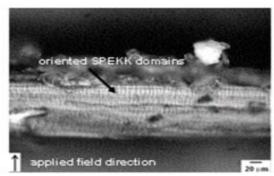
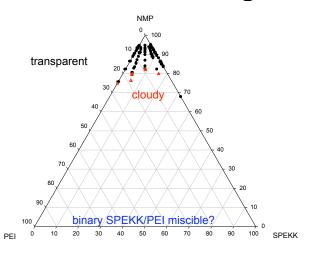


Fig. 4. 30/70 SPEKK (IEC = 1.9 meq/g)/PEI blend membrane oriented at  $200^{\circ}$ C in an electric field (1 kV/cm; f = 20 Hz) applied across the thickness of the membrane

#### sPEKK/PEI Phase Diagram



#### **Improved Conductance**

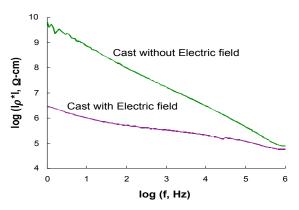


Fig. 5. Effect of EFO on the resistivity of the membrane shown in Fig. 4.

## **Technical Progress (OPM)**

**Materials Testing** 



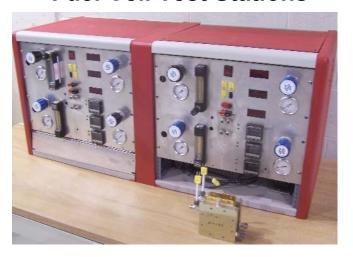
Conductance vs T & RH



**Fume Hood** 



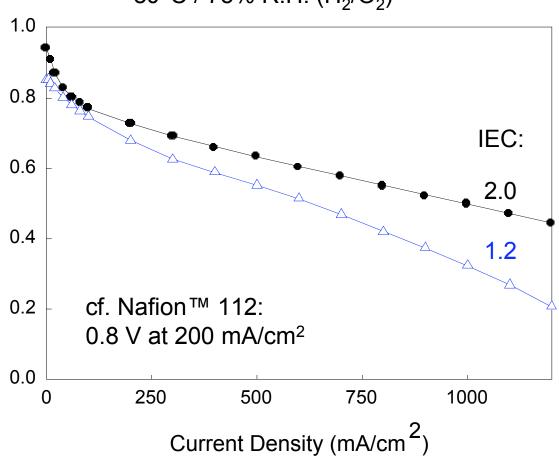
**Fuel Cell Test Stations** 



## **Technical Progress (UConn)**

#### **sPEKK-based MEA Performance**

80°C / 75% R.H. (H<sub>2</sub>/O<sub>2</sub>)



## Interactions and Collaborations

## SPEKK Blend Development: UConn

- Principal Investigators
  - + Prof. Robert Weiss
  - + Prof. Monty Shaw
- Post-Docs & Grad. Students
  - + Steven Swier
  - + Jonathan Gupton
  - + Jeffery Gaza
  - + V. J. Ramani

#### **OEM Contacts: OPM**

- Honda
- GM
- Proton Energy
- FumaTech

## **Future Work**

- FY 2004: Feasibility of sPEKK-Based MEAs
  - Measure: sPEKK Blend Conductance vs T & RH
  - Fabricate: sPEKK based MEAs
  - Feasibility: Demonstrate 3 Ωcm<sup>2</sup> MEA @ 120°C
- FY 2005: Optimization of sPEKK-Based MEAs
  - Optimize: Demonstrate 3 Ωcm<sup>2</sup> MEA @ 120°C
  - Pt Loading: Show effect of reduced Pt & Ru
  - Durability: <10mV/hr @ 100 hours